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DEVELOPMENT OF AN APPLICATION FOR MANAGING THE PRODUCTION OF ORGANIC PRODUCTS USING AN ARCHITECTURE WITH BLOCKCHAIN TECHNOLOGY

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ABSTRACT

Blockchain is a technology that can transform the way the market and governments operate. With characteristics of reliability, immutability and auditability, the Blockchain generates encrypted data which goes through a horizontal validation network, ensuring the infeasibility of your data. The applicability of Blockchain could contribute to transparency in the management of supply chains and make it possible to change the way people transfer and monitor valuable physical goods online. The architecture and protocol of Blockchain technology are examined in this paper as a viable solution to challenges of practical sustainability in production and processing that create a balance between the concerns of quality, safety, and high-quality food. An application for the management and monitoring of organic product production processes will be created to link Blockchain technology with food traceability. As a result, due to its openness, immutability, and security, Blockchain could be used to store this data.

KEYWORDS: Blockchain Technology, Organic products, Node.js, Angular, MongoDB, REST Architecture

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1.0 INTRODUCTION

The traceability of the food production chain emerged as a consequence of consumers' concern with the health of the products, generated after several facts that affected people's health in several countries [1]. Contamination of food by toxic residues, sanitary crises, and even genetic manipulation has brought the need, on the part of the final consumer, to know the origin, how the consumed food was produced, and the possible risks they can present to human health [2].

Food consumption patterns are changing rapidly nowadays due to development and sustainability issues, nutritional considerations, and health-related issues.

Food safety action plans are being adopted by producers in the stages of cultivation, harvesting, classification, packaging, transport to distribution to increase the sanitary quality of the marketed product.

Even though you tend to consume organic foods, there are still many doubts about the subject, making many people hesitate to buy them. The auditability of the production chain of these products can be a solution to the problem, bringing more confidence to the consumer.

The Blockchain standard emerges as an alternative for data storage since technology natively guarantees protection against information alteration, providing centralization of information, decentralization of storage, transparency in the storage process and auditability. Any node can check the transaction history of that protocol without any prior authorization, making the use of Blockchain technology a solution for storing data referring to traceability records, bringing more confidence to the consumer who will be able to follow the product's production

chain.

1.1 Review of Literature

The global food consumer is becoming more demanding about what they consume. Feeding oneself in the 21st century has become a constant challenge [3]. Under the new agricultural economy, attributes of intensive agriculture create new challenges for practical sustainability of production and processing that promote a balance to the problems of quality, safety and good quality of food.

Modern consumers demand fresh, tasty, nutritious and safe food [4]. Therefore, it is necessary to seek the quality and transparency of food production in the market to seek transparency in the conditions of production and commercialization.

According to the information that makes up ISO 8402:1994, traceability can describe history and locate a product through recorded information [5].

Traceability simplifies problem finding, reduces product returns, and establishes accountability. Determining the responsibilities of agents on the conformity conditions of products at each stage of production is one of the essential functions of traceability [6].

Food consumption patterns are changing rapidly nowadays due to development and sustainability issues, nutritional considerations, and health-related issues. Consuming organic products alone is not enough to make us healthier; however, Naspetti et al. (2009) stated that organic products are an essential part of a healthy and sustainable diet. Traceability is now a requirement for completing fruit and vegetable import contracts in various markets around the world.

1.2 Blockchain

Blockchain is a technology that simulates a ledger, which is used in companies' accounting to record the transactions carried out by them. However, the Blockchain can be kept publicly so that everyone has access to transactions [8].Satoshi Nakamoto (2008) introduced Blockchain to guarantee irreversibility and immutability to provide security to electronic transactions [9].

The concept of Blockchain or data chain, illustrated in Figure 1, is nothing more than a distributed, transparent and verifiable consensus system. Technology has changed the way people think about exchanging money, stocks, products, services, enforcing contracts and sharing data [10].

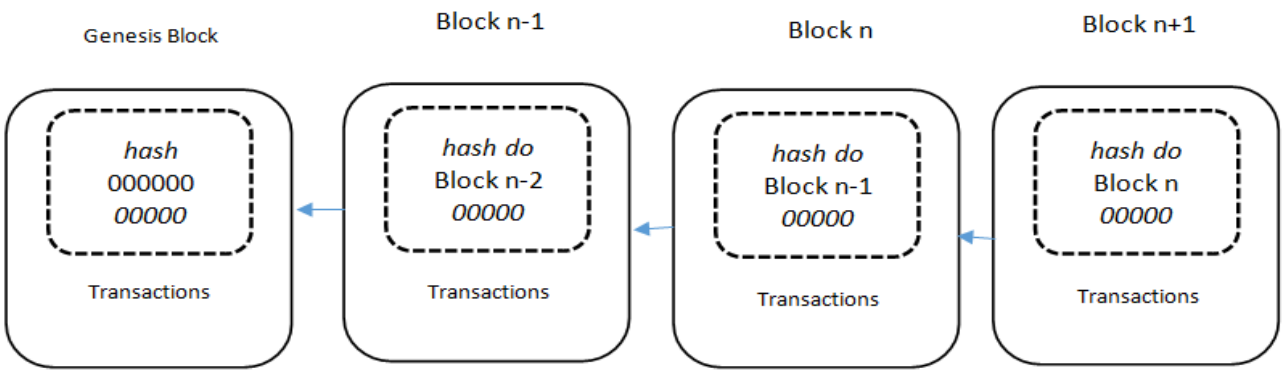

Figure 1: Representation of the Blockchain.

Blockchain technology may be used to create financial instruments such as payments, records, and smart contracts, as it avoids bad behaviour and issues like double spending and counterfeiting. Furthermore, the technology may be utilized to digitize legal and public data such as titles, birth certificates, certifications, vows, and court records. It can also be used to create "smart ownership," in which the Blockchain becomes a system for tracking, inventorying, and purchasing things like diamonds and cars. It can also be used to track the supply and food production chain, which is proposed to be used in this project, allowing chain participants to enter information in the network in an identified and openly auditable way.

2.0. METHODOLOGY

2.1 Technologies Used

In this chapter, the leading technologies used to develop the application and the Blockchain will be discussed.

2.1.1 Node.js

Node.JS was designed as a scalable web server. According to its manufacturer [11], it is a lightweight and efficient Javascript execution environment. Despite supporting several protocols, due to its Express.js framework, which extends the capabilities of the standard Node.js server by adding middleware and other capabilities such as views and routes, it is widely used to build Web applications features that support HTTP protocol. With Node.js, Javascript applications can be created to run as independent processes on the computer, instead of relying on the browser to run them, as in the past, and due to this ability, it was used in this application to execute JavaScript code and developed, both backend and frontend.

According to Tilkov (2011), Node.js has the following main characteristics:

- Single-Thread: Your applications will be single-thread; that is, each application will have an instance of one main thread per process started. Asynchronous programming and shared resources are used to make full use of the thread used;
- Asynchronous and non-blocking input and output operations – Facilitates parallel execution and resource utilization;
- Event-loop: It is event-driven.

2.2.2 Angular

Angular (Elrom, 2019) is an app design framework and development platform for creating efficient and complex single-page apps, according to the official website.

The HTML language is fantastic for describing static documents, but it falls short when it comes to declaring dynamic views in web applications. Seeking to remedy these adversities, the use of Angular to develop this application allows extending the HTML vocabulary to develop the same and making the resulting environment exceptionally expressive, readable and quick to develop.

According to Kiu et al. (2020), Angular applications are built around a design pattern called Model-View-Controller (MVC), which emphasizes creating applications that have the following characteristics:

- Extensible: You can easily enhance applications to create new and valuable features for your users;
- Maintenance: Because Angular applications are simple to debug and fix, long-term maintenance is eased.

- Testable: Testing is well supported in Angular, so you can detect and fix bugs before your users do.
- Standardized: Angular extends the web browser's native capabilities without getting in the way, allowing you to create standards-compliant online apps that use the latest technologies (such as HTML5 APIs) as well as popular tools and frameworks.

2.2.3 Mongo DB

Free, open-source, cross-platform document-oriented database software called MongoDB [15] can be used on any platform. As for MongoDB, data is stored in flexible JSON-type documents, which implies that fields can vary from document to document and that the data structure can change over time.

A NoSQL database like MongoDB does not require a schema before being used. Data of any kind can be stored on this device. This makes it easier to scale MongoDB databases than relational databases because users can create documents with any number of fields they choose. According to Nugent (2019), Documents can be used in a variety of programming languages since they can be mapped to the native data types. When documents are integrated into a system, there is less need for data binding [16].

For the development of this application, it is used to store data temporarily and store data in the format of a Blockchain.

2.2.4 REST Architecture

REST stands for Representational State Transfer, proposed by Fielding in the year 2000 [17], is described as an architectural style that consists of a set of constraints applied to elements within the architecture and used in the application as principles and rules for creating a project with well-defined interfaces, determining how HTTP and URIs should be used. According to Gao (2021), REST systems are less coupled, lighter, more efficient and flexible than systems based on other Web Services protocols. And can be easily reused. Furthermore, REST principles can be mapped to the basic methods of the HTTP protocol (GET, POST, UPDATE and DELETE) to create CRUD (Create, Read, Update, Delete) systems of a RESTful application capable of applying REST principles.

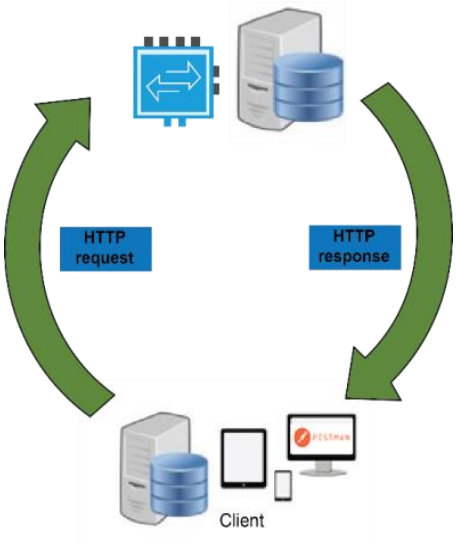

Figure 2: RESTful Web Service Architecture

3. PROPOSED APPLICATION

The application aims to manage the processes carried out by the producer to produce organic products. The producer has the possibility of separating his production into batches or products. In each batch, he records all the processes carried out in the production, for example, green manuring, irrigation, soil treatment, etc. adopted in the production, and serving as an instrument for the verification of the steps of the same, as the processes carried out in the production of organic products.

All processes registered by the producer are sent to a Blockchain network, where they become immutable and transparent, thus giving the final consumer the possibility to view all these steps carried out in production, guaranteeing the origin of the product.

4.0 APPLICATION DEVELOPMENT

For the development of the application, the following were used: the non-relational MongoDB database for the temporary storage of records before persistence in the Blockchain network; the NodeJS backend platform; of the Express framework; Angular framework for frontend development; the REST architectural model for Web integration; and JSON data formatting to communicate with the API. Figure 3 shows the flow of operations that involved such an application. The components necessary for the application to work were illustrated in a simplified way to detail the process. In this way, the data received from the application through HTTP requests (Sequence 1) is handled by an API with definitions and protocols for communicating this data. The REST standard is used so that HTTP requests meet the guidelines defined in the architecture.

They are persisted after processing the data (Sequence 2) using the MongoDB database. This data is temporarily stored so that it is then definitively and immutably inserted into the Blockchain network (Sequence 3).

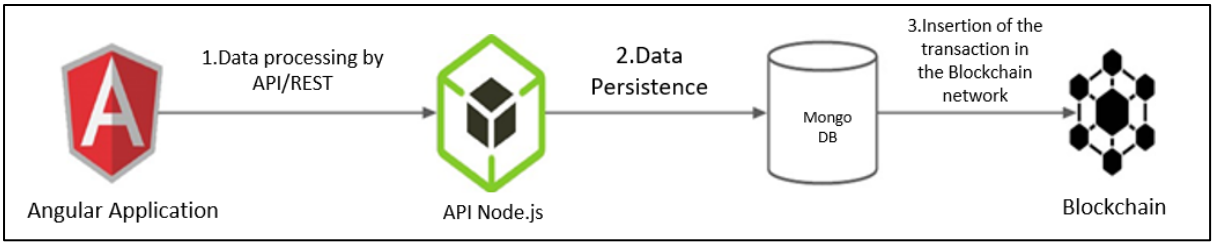

Figure 3: Flow of Operations

4.1 Application Modeling

This section will demonstrate through diagrams how the application's working flow will be and a perspective of the main functionalities that the application will have for it to work correctly.

4.1.1 Use Case Diagram

The Use Case Diagram's main objective is to demonstrate the application's operating flow from the user's point of view. This provides an overview of the system's operation and explains the system's main features to make available to users.

The diagram presented in Figure 4 demonstrates the main features that the application will provide to the users involved who will use the system.

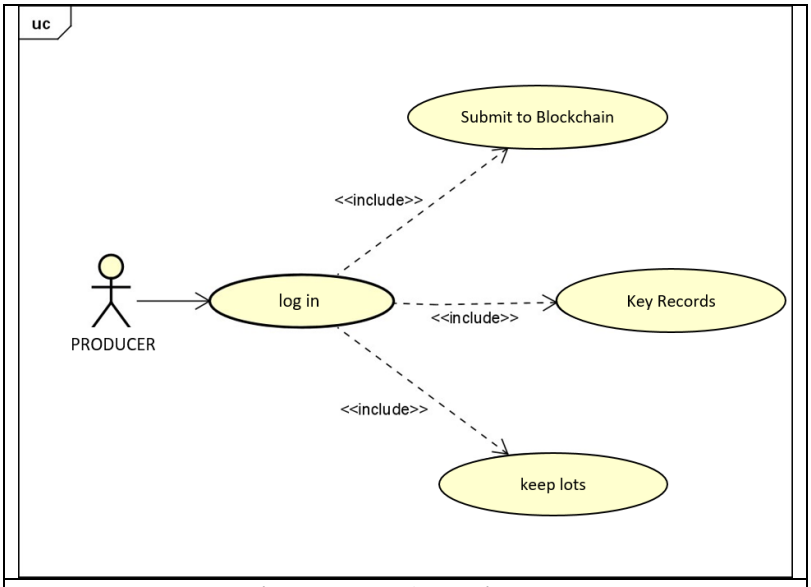

Figure 4: Use Case Diagram

4.1.2 Description of Use Cases

The description of the use cases aims to provide a detailed overview of the main functionalities that the system will provide to the actors through the use cases that were developed and explained as below;

Producer:

- Send to Blockchain: The Producer sends the records made to the Blockchain network.
- Keep Records: The Producer records all production processes.
- Keep Lots: The Producer inserts the lots or products recorded in the processes carried out in production.
- Log in: The Producer logs in with his data to access the application.

4.2 Features And Functionalities

This section describes the features implemented in the application, showing which features and technologies were used.

4.2.1 User authentication

This feature was developed using the JSON Web Token standard. Through this standard, the management of registered users is carried out, and the registration of new users in the application through e-mail and password. The user will send an HTTP authentication request to the API. In it, the user sends data such as e-mail address and password in the body of the request. Once the data sent by the user has been authenticated to the server, the server will create a JWT token signed with an API internal secret and send this token back to the user. Provided with the authenticated token, the user has access to application resources that were previously restricted. To perform this access, it is necessary to inform this token in the request's Authorization header.

4.2.2 Insertion of Batches and Processes

The user can insert, edit and delete batches, as well as register, edit and delete the processes carried out in each batch. As shown in Figure 5, the buttons are displayed when the user hovers over the desired process to edit or delete. This data is

temporarily inserted into a database created using MongoDB.

The "Send to Blockchain" button has the function of sending the registered process to the Blockchain network definitively since after being inserted into the Blockchain, due to being an encrypted bank and referenced with its hash, which guarantees that this data has not been changed, it can no longer be modified or deleted.

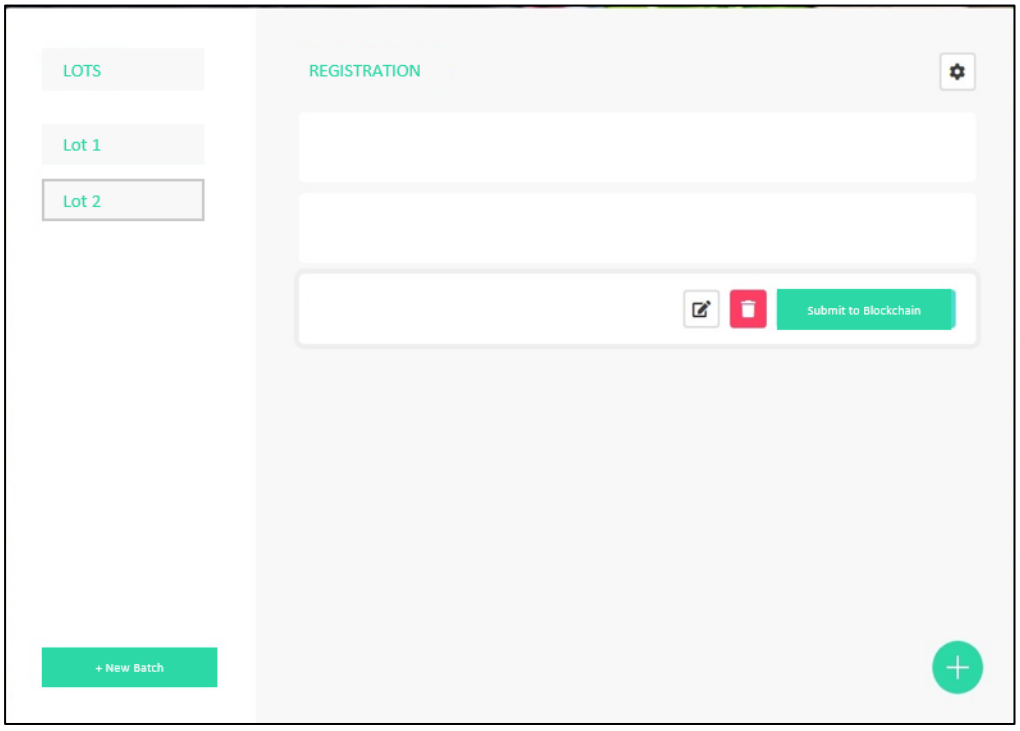

Figure 5: Main Screen

4.2.3 Sending to Blockchain

The Blockchain network was implemented following the model proposed by Maboud (2020), developing a Blockchain structure using the MongoDB database, adapted for an API capable of receiving REST requests, and inserting the data using the object data modeling library. (ODM) Mongoose provides a modelling environment for your data, reinforcing the structure as needed while maintaining flexibility, making MongoDB more effective. After clicking on the "Send to Blockchain" button described in the previous section, the function "create a blockchain" is called, passing the process as a parameter.

This function has the objective of sending the controller the process and the batch id that this process belongs to. The controller receives this data and requests the web service to be inserted into the Blockchain.

The controller receives this request and then uses the POST method, uses the HTTP protocol, communicates with the API through REST requests, and passes the resource identifier and the object with the data as parameters.

The API receives this POST request, fetches the data passed as a parameter and creates the "block" variable, the block to be inserted into the Blockchain, following the data schema shown in Scheme 2. Then it generates a hash for the block created using the library object-hash and fetches the previous block's hash, thus one block depending on the other and forming a chain of blocks.

This block is inserted into the Blockchain network if everything is in agreement, as shown in scheme 1.

```
app.post('/blockchain', (req, res) => { let prevHash = 0;
  let index = 0;

  Blockchain.findOne().sort({ _id: -1 }).limit(1).exec((err, data) => { prevHash =
    data.hash;
    index = data.index + 1;

    let block = { index: index,
      timestamp: Date.now(),
      lote: req.body.selectionLoteId, process: req.body.
      process, prevHash: prevHash,
      hash: hash(prevHash)
    };

    //Add a instance and Save to DB
    let newBlock = new Blockchain(block); newBlock.save((err) => {
      if (err) return console.log(chalk.red(" Error saving DB ", err.message));
      console.log(chalk.green(" Block save not BD!"));
    });

    console.log(block);

  });
});
```

Scheme 1: Insertion of the Block in the Blockchain


```
_id: ObjectId("5fc146924678d0221ce5038d")
timestamp: 2020-11-27T18:33:54.625+00:00
index: 0
lote: "5fb6bc7e710eca25c47b5f0b"
processo: "GENESIS"
prevHash: null
hash: "63d0b026e716c2f15878d2b9d7ff673afe0f9916"
__v: 0

_id: ObjectId("5fc146e8f3637d00bce4ad9e")
timestamp: 2020-11-27T18:35:20.554+00:00
index: 1
lote: "5fb6bc7e710eca25c47b5f0b"
processo: "Irrigação"
prevHash: "63d0b026e716c2f15878d2b9d7ff673afe0f9916"
hash: "37f0eb124eb134bf921797edc1d6a75291dccbf7"
__v: 0

_id: ObjectId("5fc146ebf3637d00bce4ad9f")
timestamp: 2020-11-27T18:35:23.697+00:00
index: 2
lote: "5fb6bc7e710eca25c47b5f0b"
processo: "Adubação"
prevHash: "37f0eb124eb134bf921797edc1d6a75291dccbf7"
hash: "ee6bd726a588810e9d7faebca50a40ab5c69b429"
__v: 0
```


Scheme 2: Example of Data Saved on Blockchain

5. CONCLUSIONS

Using Blockchain technology as a way to assist in the security of traceability of the food production chain, having as an example the production chain and production of organic products, we can conclude that Blockchain becomes efficient as a result of its ability to auditability, transparency and immutability due to its hash code assignment structure by chaining all the blocks in the chain. Another alternative to employing Blockchain as a storage service is to use one of the cloud Blockchain services available on the market. But due to the high price of these services and the difficulty of integrating with a web service application, the creation of a Blockchain structure using a non-relational database adapted to the insertion of data with a REST API was developed to communicate the application with the Blockchain structure.

For future work, a range of possibilities is opened that meets this theme, such as generation of QR Code for the visualization of processes more efficient for the final consumer, different applicability of the application in other means that traceability can be a solution, etc.

REFERENCES

1. *Chhikara, Navnidhi & Jaglan, Sundeep & Sindhu, Neelesh & Venthodika, Anshid & Charan, Manga & Panghal, Anil. (2018). Importance of Traceability in Food Supply Chain for Brand Protection and Food Safety Systems Implementation. Annals of biology. 34. 111-118.*
2. *Gay, Paolo & Dabbene, Fabrizio & Tortia, C.. (2013). Traceability issues in food supply chain management: A review. Biosystems Engineering. In press. 10.1016/j.biosystemseng.2013.09.006.*
3. *Cooper, Richard & Smil, Vaclav. (2000). Feeding the World: A Challenge for the Twenty-First Century. Foreign Affairs. 79. 177. 10.2307/20049992.*
4. *Beltran-Peña, Areidy & Rosa, Lorenzo & D'Odorico, Paolo. (2020). Global food self-sufficiency in the 21st century under sustainable intensification of agriculture. Environmental Research Letters. 10.1088/1748-9326/ab9388.*
5. *Cherqui, Frédéric & S, Baati & Belmeziti, Ali & B, Chocat & P, Le & D, Granger & B, Loubière & Nafi, Amir & C, Sebastian & A, Tourne & J.-Y, Toussaint & Vareilles, Sophie & Werey, Caty. (2014). Outil Methodologique d'aide à la Gestion intégrée des eaux urbaines.*
6. *Trautman, Dawn & Goddard, Ellen & Nilsson, Tomas. (2008). Traceability -- A Literature Review. The University of Alberta, Department of Rural Economy, Project Report Series.*
7. *Naspetti, Simona & Zanoli, Raffaele. (2009). Organic Food Quality and Safety Perception Throughout Europe Organic Food Quality and Safety Perception. Journal of Food Products Marketing. 15. 249-266. 10.1080/10454440902908019.*
8. *Song, Ju Myung & Sung, Jongwook & Park, Taeho. (2019). Applications of Blockchain to Improve Supply Chain Traceability. Procedia Computer Science. 162. 119-122. 10.1016/j.procs.2019.11.266.*
9. *Tasca, Paolo & Tessone, Claudio. (2019). A Taxonomy of Blockchain Technologies: Principles of Identification and Classification. Ledger. 4. 10.5195/ledger.2019.140.*
10. *Pawar, Shankar & Saraf, Aditya & Parade, Sanket & Sharma, Shabnam. (2018). Review on Blockchain Technology. International Journal of Computer Applications. 182. 40-41. 10.5120/ijca2018918288.*
11. *Chopra, Umesh & Rathore, Ayush & Pandey, Rajiv. (2020). Rendering Blockchain Immutability in Chat server: A Node.js Approach. 10.1007/978-981-15-3643-4_10.*
12. *Tilkov, Stefan & Vinoski, Steve. (2011). Node.js: Using JavaScript to Build High-Performance Network Programs. Internet*

Computing, IEEE. 14. 80 - 83. 10.1109/MIC.2010.145.

13. *Elrom, Elad. (2019). Build Dapps with Angular: Part I. 10.1007/978-1-4842-4847-8_9.*
14. *Kiu, Mee San & Chia, Fah Choy & Wong, Phui Fung. (2020). Exploring the potentials of blockchain application in the construction industry: a systematic review. International Journal of Construction Management. 10.1080/15623599.2020.1833436.*
15. *Minh Son, Nguyen & Nguyen, Thanh-Lam & Huong, Phan & Hien, Lam. (2021). Novel System Using Blockchain for Origin Traceability of Agricultural Products. Sensors and Materials. 33. 601. 10.18494/SAM.2021.2490.*
16. *Nugent, Monica & Lennon, Ruth. (2019). Blockchain for Decentralized Data Analysis. 1059-1060. 10.1109/INFCOMW.2019.8845244.*
17. *Geneiatakis, Dimitris & Soupionis, Yannis & Steri, Gary & Kounelis, Ioannis & Neisse, Ricardo & Nai Fovino, Igor. (2020). Blockchain Performance Analysis for Supporting Cross-Border E-Government Services. IEEE Transactions on Engineering Management. PP. 1-13. 10.1109/TEM.2020.2979325.*
18. *Gao, Yang & Wu, Wenjun & Si, Pengbo & Yang, Zhaoxin & Yu, Fei. (2021). B-ReST: Blockchain-Enabled Resource Sharing and Transactions in Fog Computing. IEEE Wireless Communications. PP. 1-9. 10.1109/MWC.001.2000102.*
19. *Chavan, Amrita B., and K. Rajeswari. "The design and developement of decentralized digilocker using blockchain." International Journal of Computer Science Engineering and Information Technology Research (IJCSEITR) 9 (2019): 29-36.*
20. *Miraz, Mahadi Hasan, et al. "Factors Affecting Consumers Intention to Use Blockchain-Based Services (BBS) in the Hotel Industry." International Journal of Mechanical and Production Engineering Research and Development (IJMPERD) 10.3 (2020): 8891-8902.*
21. *Bangar, Ashwini, and Swapnil Shinde. "Study and comparison of cryptographic methods for cloud security." Int J Comput Sci Eng Inf Technol Res 4.2 (2014): 205-213.*
22. *Jayaram, B., et al. "A Survey On Social Media Data Analytics And Cloud Computing Tools." International Journal of Mechanical and Production Engineering Research and Development, 8 (3) 243 (2018): 254.*